Inclusive Electroproduction with CLAS12 and Nucleon Structure in the Valence Quark Domain

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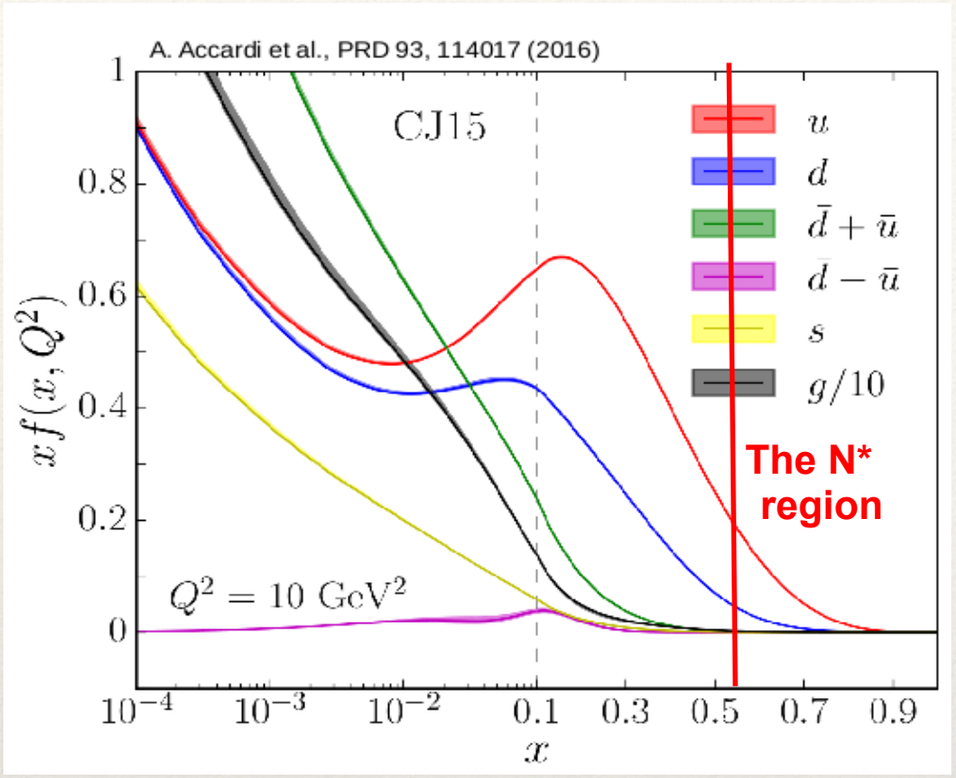
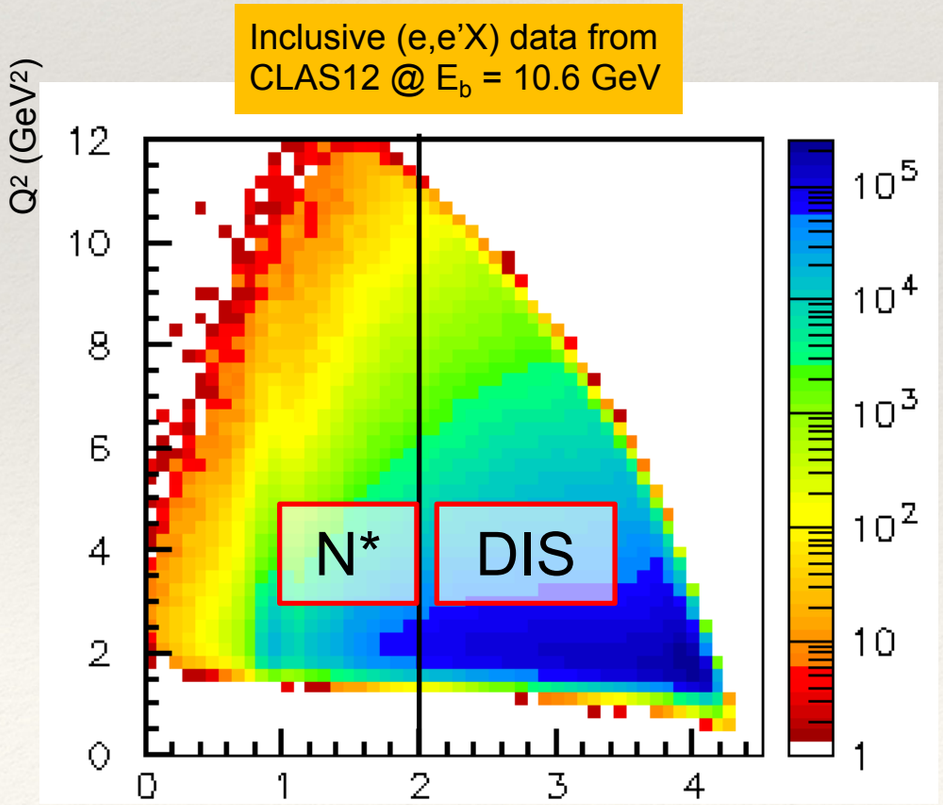
Overview

- Introduction and motivation
- Data analysis
- Results
- Next steps and outlook
- Summary

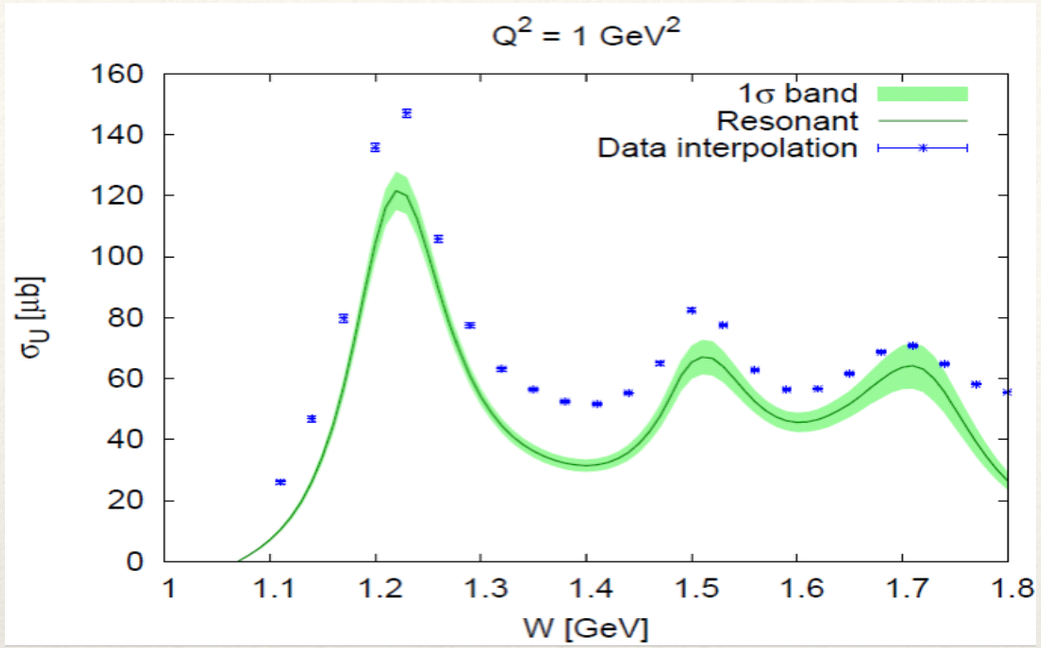
Extending Knowledge of the Nucleon PDF in the Resonance Region

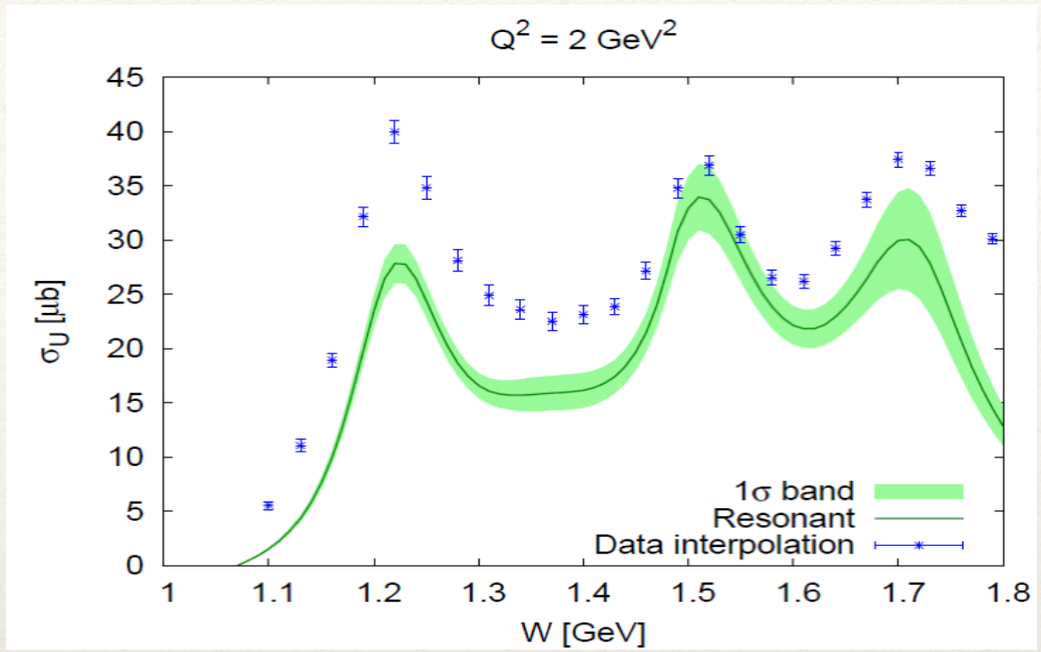


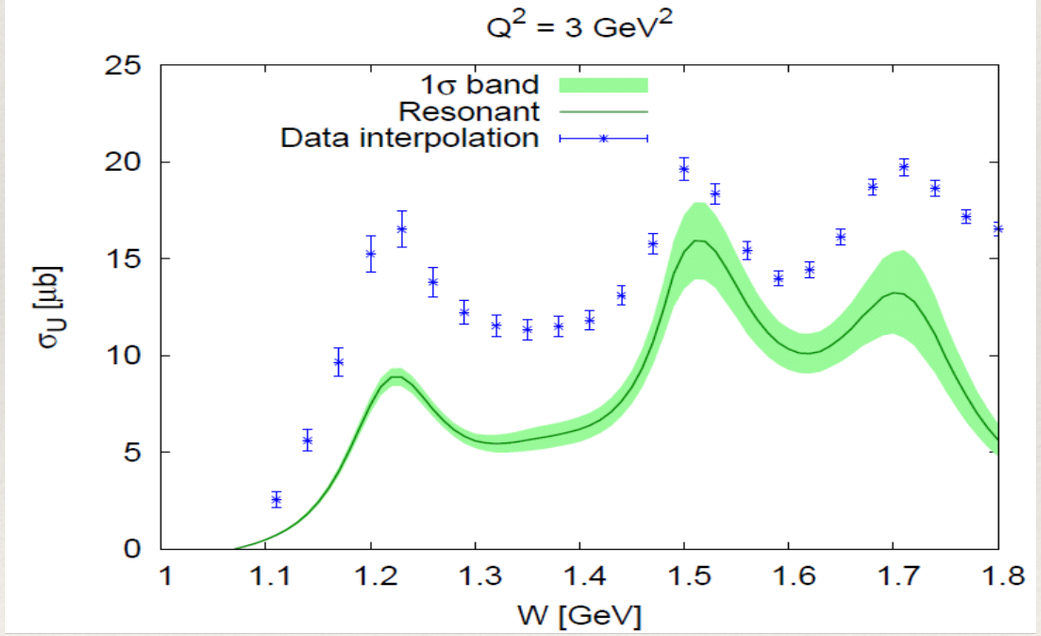


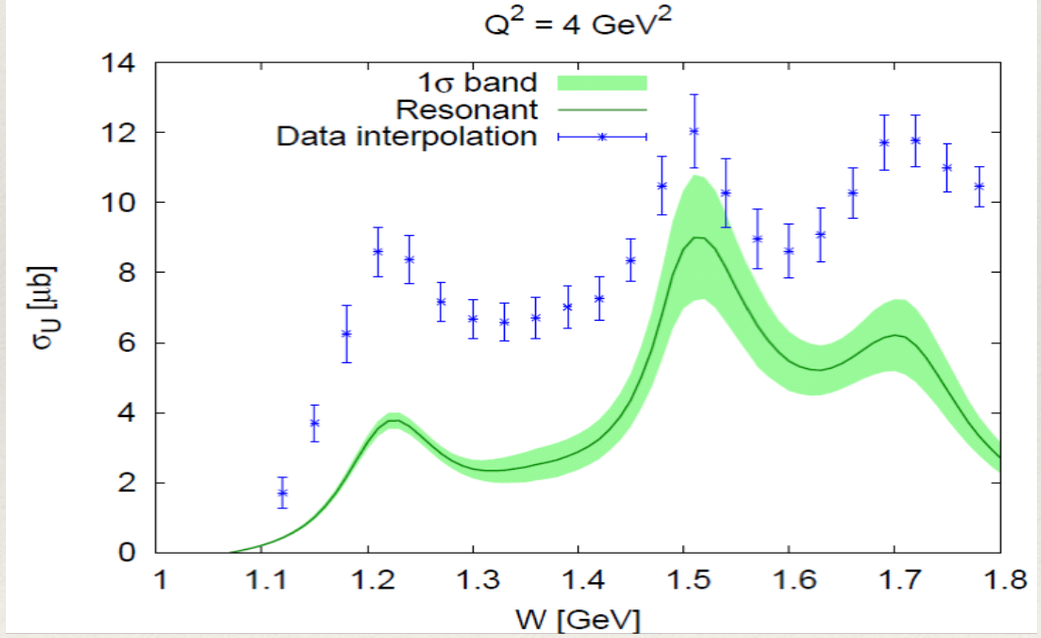
- Study of ground state nucleon PDF from inclusive electron scattering offers an effective tool for nucleon structure exploration
- The global QCD-driven analyses have provided detailed information on the quark and gluon PDFs in a wide range of Bjorken variable x_B from 10^{-4} to above 0.9 and at photon virtualities Q^2 from 1 - 10^4 GeV^2
- PDF studies in the resonance region (W<2.0 GeV or x_B >0.6) require accounting for resonance contributions
- Hall A/C provided accurate (e,e'X) data in resonance region; due to limited acceptance, data are available on correlated (W,Q^2) grid and offer limited W-coverage at a given Q^2 – a few 100 MeV at Q^2>4.0 GeV^2
- (e,e'X) data from CLAS12 with almost 4π-acceptance cover the W-range from pion threshold to >3.0 GeV in all Q^2-bins
- CLAS12 data offer opportunities to explore evolution of the ground state nucleon PDF at distances where the transition from the strong-QCD to pQCD regimes is expected

Resonance Contributions into the Virtual Photon Cross Sections





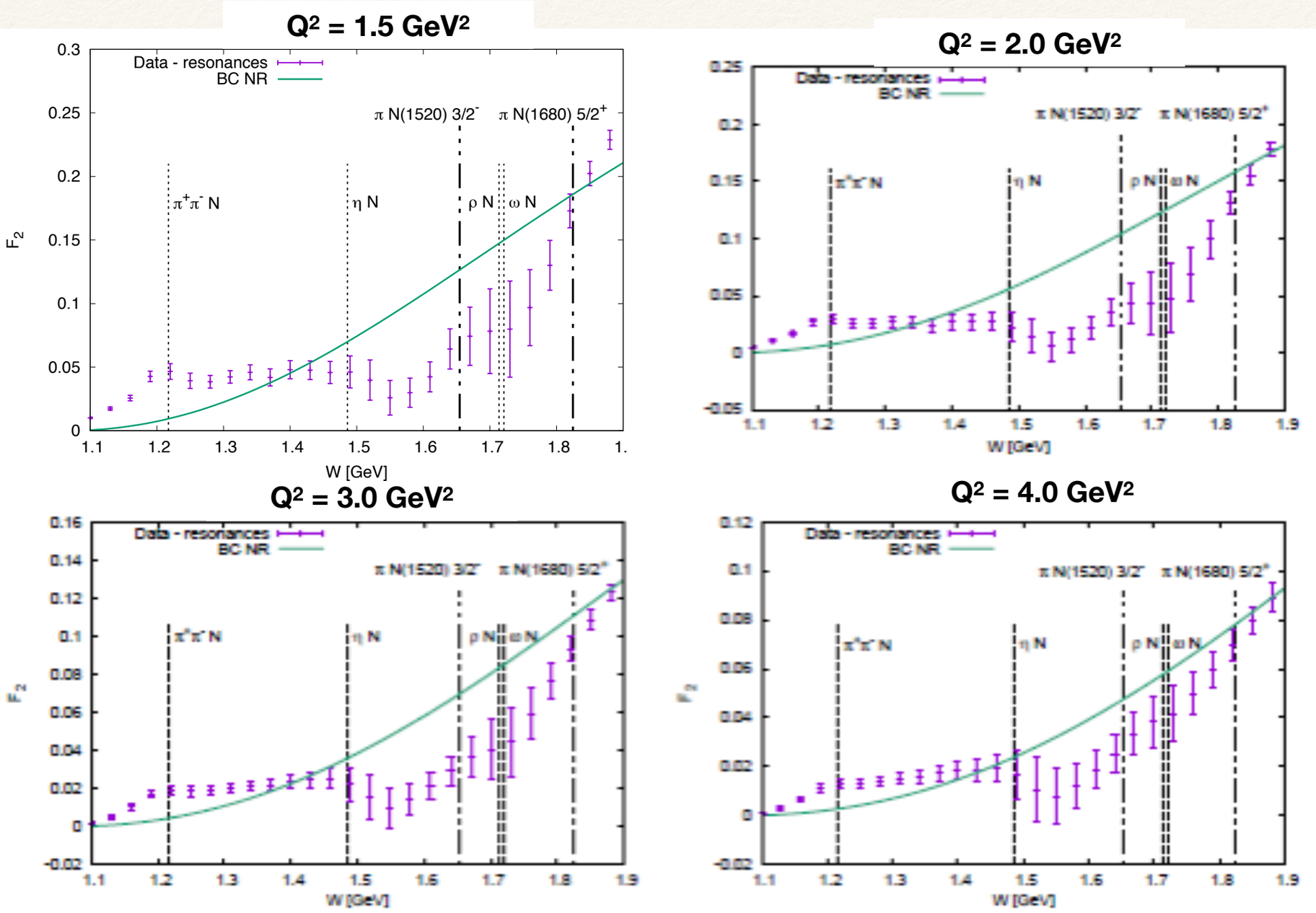




For the first time the resonant contributions were evaluated from the experimental results on the $\gamma_v pN^*$ electrocouplings from CLAS at W<1.8 GeV

A.N. Hiller Blin *et al.*, Phys. Rev. C 100, 035201 (2019)

Impact of the Resonant Contributions to Insight of PDF



F2 structure function from the Extrapolation from DIS
M.E.Christy, P. Bosted, PRC 81, 055213 (2010)

F_2 structure function after subtraction of resonant contributions

- Difference in the resonance region between the subtracted F2 and the non-resonant contributions obtained by just extrapolating from the DIS region, demonstrate a significance of realistic evaluation of the resonance contributions to the measured F2 for the insight to the ground nucleon PDF.
- Analysis method for realistic evaluation of the resonance contribution to the CLAS12 (e,e'X) data has been developed and published in A.N. Hiller Blin et al., Phys. Rev. C100, 035201 (2019)

Data analysis

Data

10.6 GeV electron beam
5 cm liquid hydrogen target

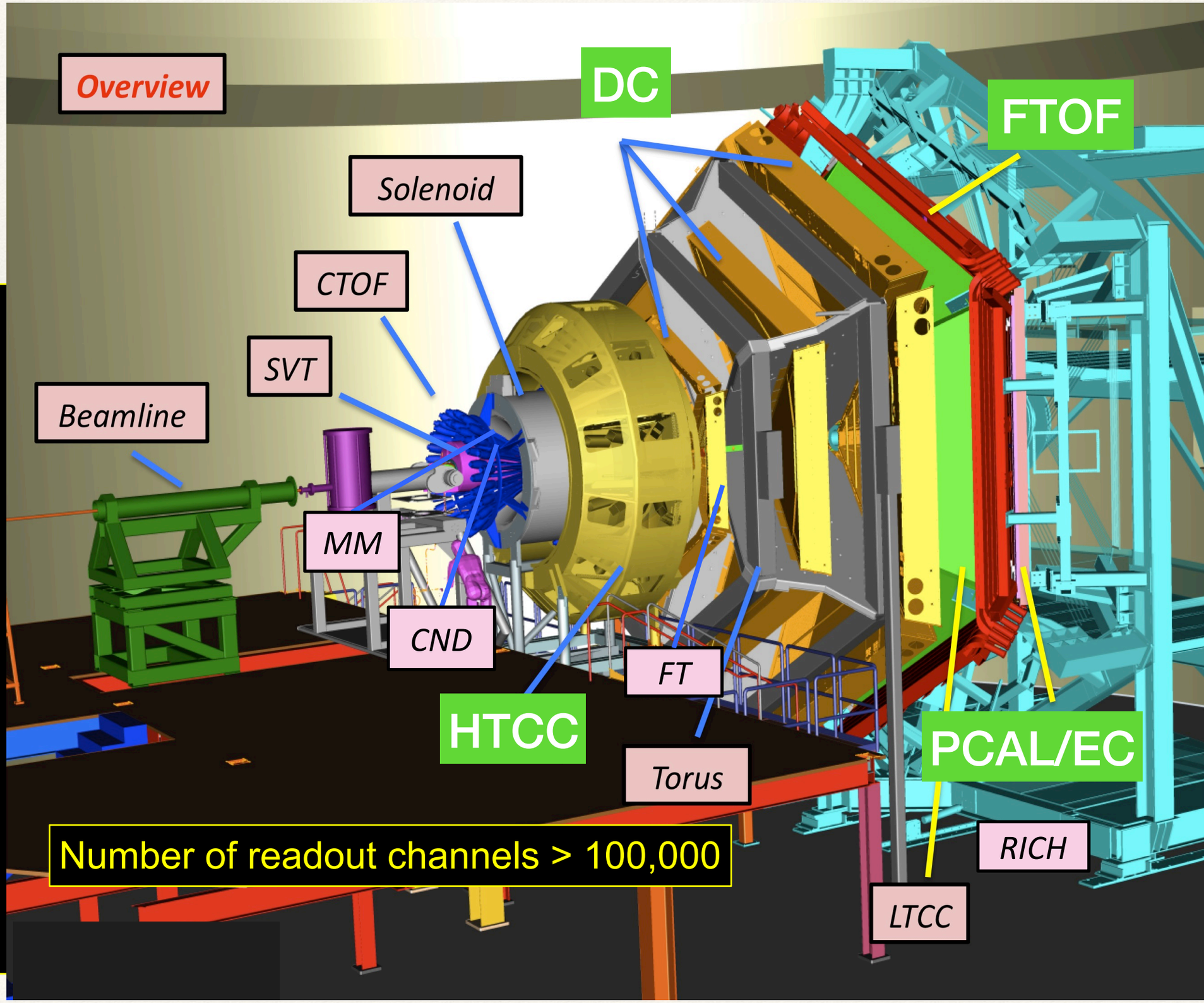
Electron ID

Forward Detector (FD)

- TORUS magnet
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward ToF System
- Pre-shower calorimeter
- E.M. calorimeter
- Forward Tagger
- RICH detector

Central Detector (CD)

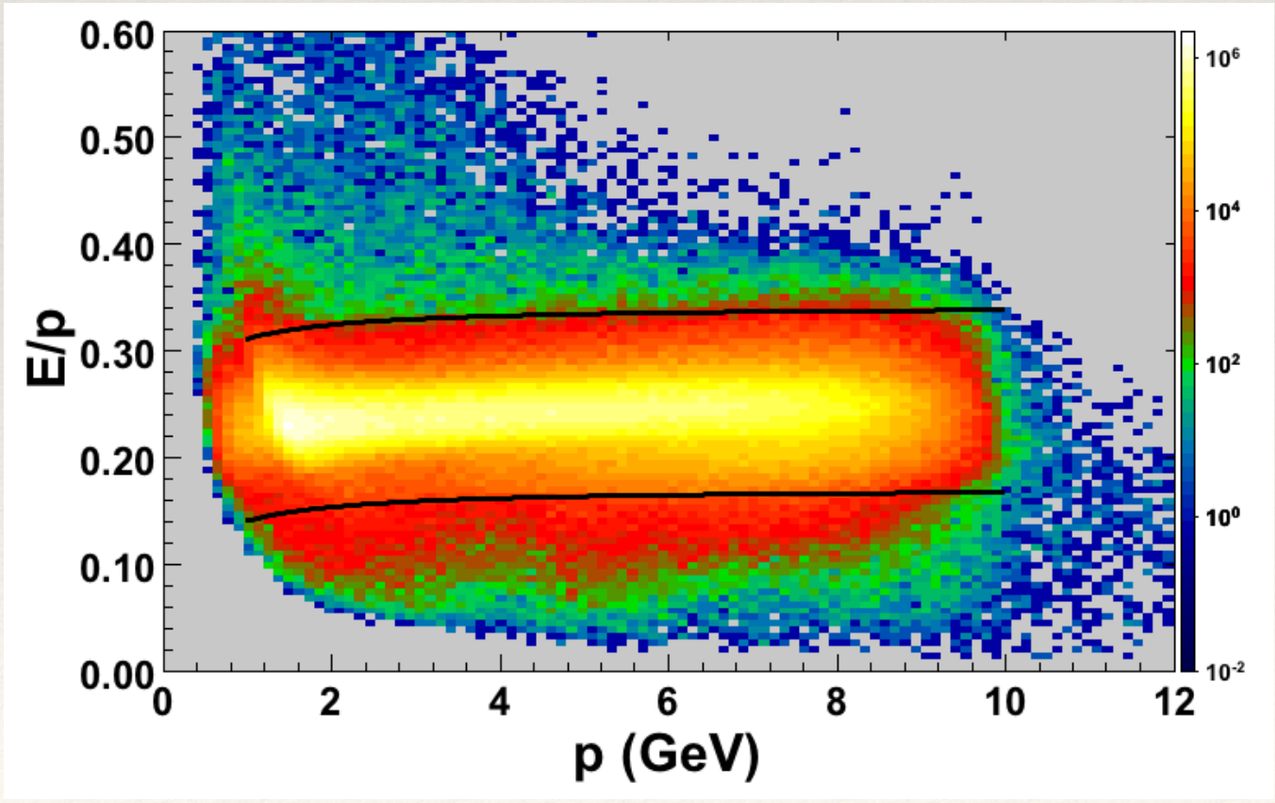
- Solenoid magnet
- Silicon Vertex Tracker
- Central Time-of-Flight
- Central Neutron Detector
- MicroMegas



Data analysis

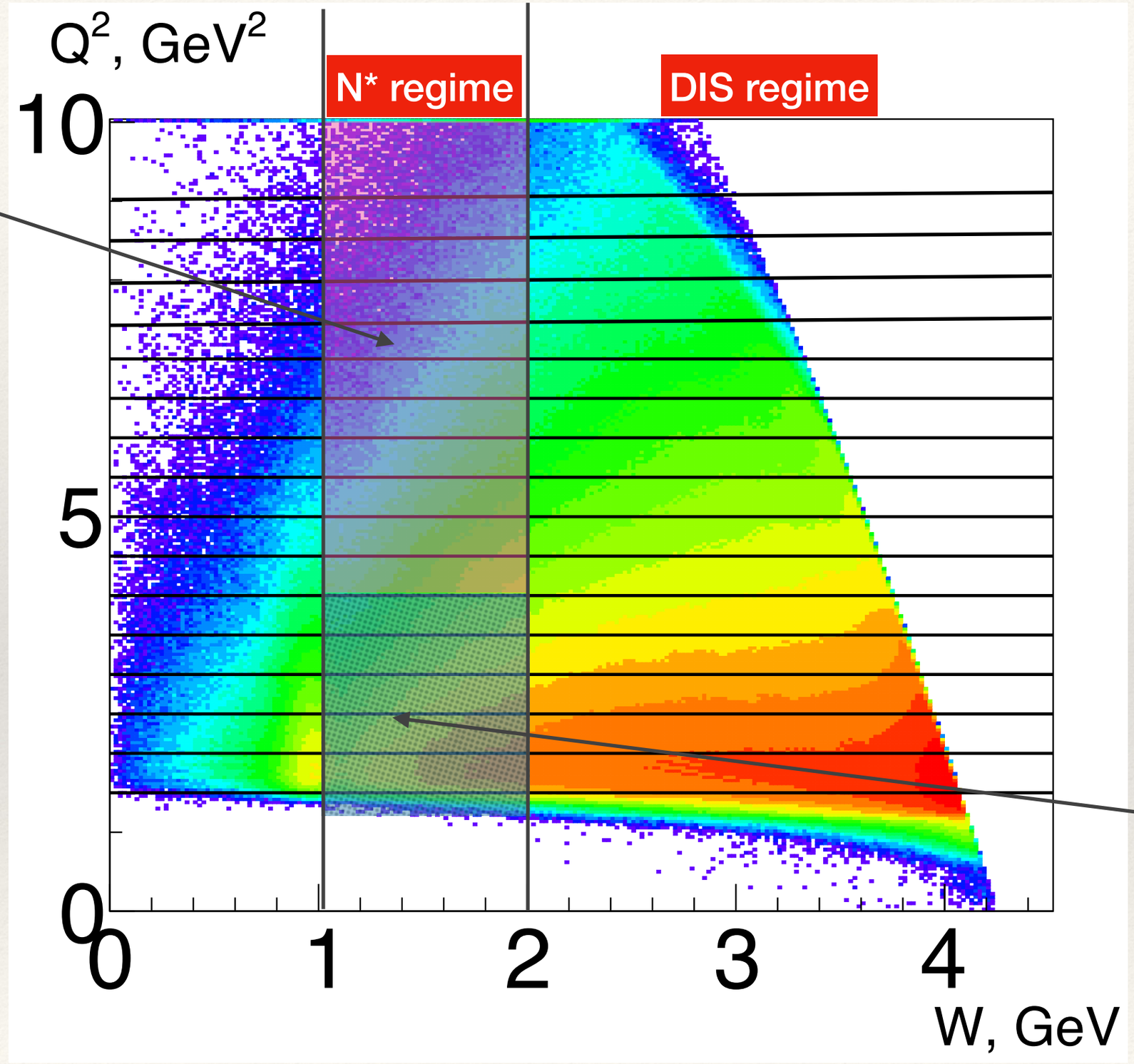
Electron ID

- Limited to Forward Detector (5 -35 degrees coverage in polar angle)
- Electrons are selected by the CLAS12 Event Builder
  - Negative track with a hit in TOF, ECAL and HTCC;
  - 2.0 photoelectrons in HTCC;
  - 60 MeV in PCAL;
  - 5-sigma cuts on a parameterized momentum-dependent sampling fraction.



Forward Calorimeter
sampling fraction for electrons

Coverage and Binning



Binning:
ΔW: 0.025 GeV
ΔQ²: 0.5 GeV²

We will report data in the Q² region up to 10 GeV².

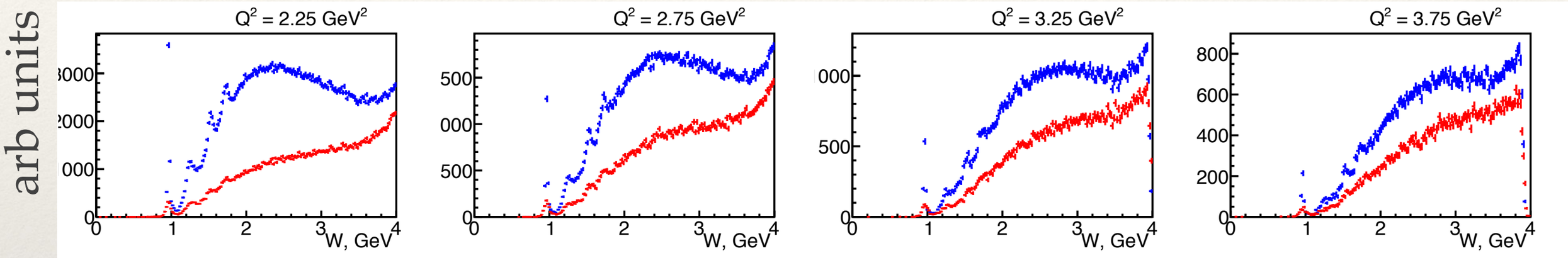
Acceptance and Luminosity Corrections

Generated events

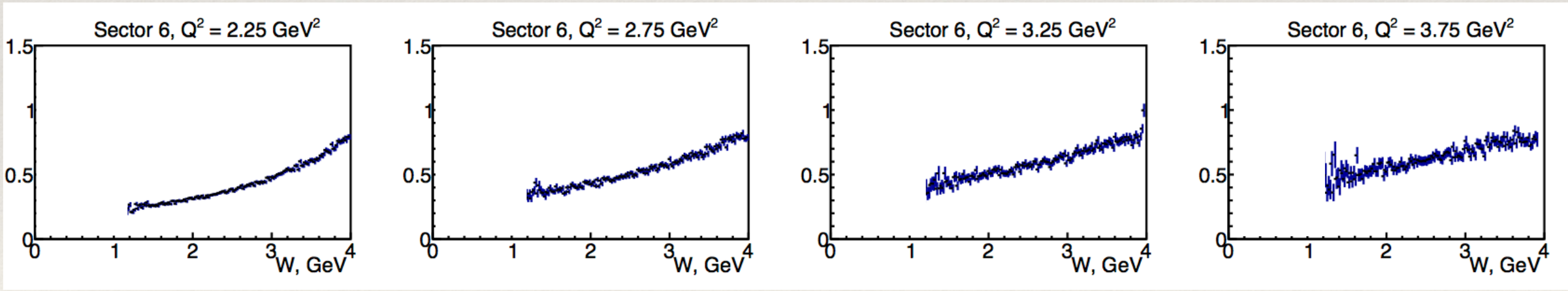
Reconstructed simulation events

Inclusive event generator: M. Sargsyan, CLAS-NOTE 90-007 (1990).
Includes elastic and radiative effects

Same reconstruction algorithms are used between data and simulation.
Both generated and reconstructed events display main features of inclusive electron cross section, namely elastic peak, resonance region with “bumps” and smooth DIS region.



Acceptance Correction

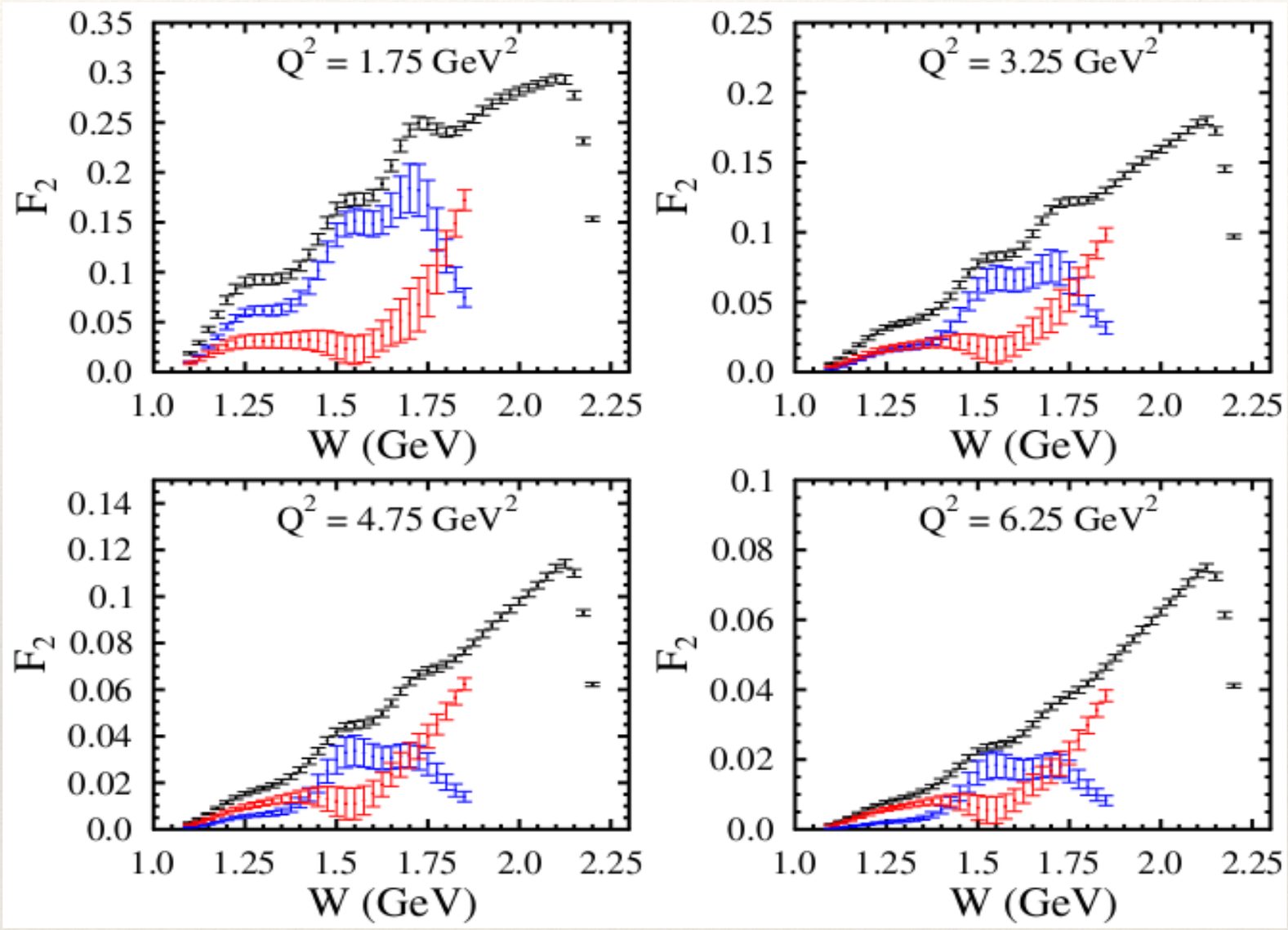


Sample of the acceptance correction for a few Q^2 bins

Luminosity Correction

Luminosity correction is based on the geometry and properties of the target (5 cm long liquid hydrogen) and live-time corrected integrated beam charge on the Faraday Cup.

Gaining Insight into the Ground State Nucleon PDF in Resonance Region



Hall B/JPAC:
A.N. Hiller Blin,
V.I. Mokeev

World data Gaussian smeared with CLAS12 W-resolution

Resonant contributions

F_2 after subtraction of resonant contributions

- F_2 decomposition through the resonant/non-resonant contributions offers full information from the side of experiment for the extraction of the ground state nucleon PDF in the transition from strong-QCD to pQCD
- Recent advances in theory make it possible to evaluate the ground state nucleon PDF starting from the QCD Lagrangian:

Y.Q. Ma, J.Qiu, PRL 120, 022003 (2018), A.V. Radyushkin, PRD 96, 034025 (2017)

Future plans

- Improvement of electron ID procedure;
- Better understanding of detector/tracking efficiency;
- Radiative corrections;
- Better understanding of the CLAS12 resolution;
- Improvement of simulation.

Summary

- Preliminary results on the inclusive electron scattering cross section are available from the CLAS12 in the kinematic area of 1.1 GeV <W< 4.0 GeV and 1.5 GeV^2 < Q^2 < 10 GeV^2;
- The approach for the evaluation of the resonance contributions to inclusive electron scattering based on the CLAS results on γ_vpN* electrocouplings has been developed and applied to this dataset;
- Inclusive electron scattering data from CLAS12 and the evaluated resonant/non-resonant contributions will provide insight into the ground state nucleon PDF in the resonance region and will shed light on the onset of quark-hadron duality;
- The CLAS12 Q^2 coverage will allow for the exploration of the ground state nucleon PDF at distance-scales where the transition from strong- to pQCD is expected.

CEBAF Large Acceptance Spectrometer

Jefferson Lab